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HOUSE-DRAINAGE AND SEWERAGE.

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House-Drainage and Sewerage George E. Waring, Jr.

HOUSE-DRAINAGE AND SEWERAGE.*

By George E. Waring, Jr.

I.—HOUSE-DRAINAGE.

A CHIEF justification for the spending of large sums in city drainage, is to be sought in the *sanitary* benefits of the work. The first great purpose is to promote the health of the community.

Believing that the good or bad drainage of our houses has far more to do with the sick-rate and the death-rate than the good or bad drainage of our streets has, I place the house-drainage question first in order, as it is first in importance.

It is an unfortunate fact, which we cannot evade, that all human life involves the production of refuse matter. The economy of the person and the economy of the household, present this constant condition. In proportion as individuals and households are congregated together, does the difficulty increase. In one respect, the disposal of refuse matters forms an exception to the general law, that "in union there is strength." So far as possible, sanitary authorities should adopt as their motto, "Divide and Conquer." The more we unite our offscourings, the more do we increase our difficulty in their proper disposal. It is a simple matter to care for the liquid and solid wastes of a single family, living in a house by itself, and surrounded by ample ground; but it is a very difficult matter,—it is indeed the most difficult problem with which modern engineering has to deal,—to take proper care of the wastes of thousands of families, living close together in a town. In the former case, the ground itself, in the immediate vicinity of the house, affords ample means for safe and easy disposal. In the case of the town, where public sewers are required for the removal of the fouled waters of the community, we are overwhelmed with the volume of that with which we have to deal.

At the same time, whether the drainage waters of the house are to be cared for in its own garden, or discharged into the public sewer, the conditions of its interior drainage are essentially the

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same. We will assume that there is no question as to the ultimate disposal of our drainage, and that we have to concern ourselves only with its removal beyond the walls of the house.

It is well known that water, containing organic matter, if left to itself, becomes fouled by the decomposition of its impurities; and that vessels, whose sides have become soiled by dirty water which they have contained, soon become offensive.

Our pipes and drains are made for the express purpose of carrying away waste matters, and even a soil-pipe "cannot touch pitch and not be defiled." Every conduit intended for the removal of dirty liquids and semi-solid filth, must become more or less slimed by adhesions, and the adhering matter is of a decomposable character. Even the thin coating of soap and of the dirt of ablution, lining the outlet pipe of a wash-basin, wastes itself away in the production of the gaseous results of decomposition. Whether it be much or little, so far as it is not washed on to the drain, it converts itself into "sewer gas," and seeks such means of escape as the plumber may have left for it. Even a tin slop-basin, standing at the side of a wash-stand, unless daily rinsed after emptying, becomes offensive, in spite of its free exposure to light and air. Its smell comes, not from the evaporation of its liquid contents when full, but from the decomposition of the slight coating of foul matters adhering to its sides after it has been emptied.

The decomposition, of precisely the same matters, takes place inside of the waste-pipe of a stationary basin, but here it takes place in a confined space, insufficiently supplied with air. For lack of air, the chemical changes are of a different, and are believed to be of a more dangerous, character. The resolution of organic matter into its gaseous elements, implies the absorption of oxygen. So long as this element can be supplied by the air, so long the dissolution is of a normal character, producing as its final result the simple elements of which all organic matter is chiefly made up —sulphur, phosphorus, carbonic acid, hydrogen and oxygen (combined as water), and nitrogen (in the form of nitric acid and ammonia). The intermediate combinations between the organized form and the ultimate result, are more or less offensive in their odor, but the ultimate products are innoxious and innocuous. When, on the other hand, there is not a sufficient supply of air to furnish the oxygen required, then this element is taken from the decom-

posing material itself. The decomposition goes on, but, lacking its natural food, it feeds on its own body, and the whole process is deranged, producing sulphuretted hydrogen, phosphoretted hydrogen, carburetted hydrogen, carbonic oxide, nitrous oxide, and other offensive and dangerous gases.

Of course, the waste-pipe of a wash-basin—only a few feet long, and of small circumference—does not contain enough material to produce a very serious effect, but it is probable that the foul smell we so often get from a basin, comes more frequently from its own waste-pipe than from the street sewer with which it is connected.

The waste-pipe of a butler's sink is still worse in the character of the decomposition of its slime, because it is coated with grosser materials; the kitchen waste is fouler yet; and when we come to that grand combination receptacle of all domestic foulness, the soil-pipe and the drain leading away from it, we may well stand aghast at their possibilities for offence and mischief. We are much given to ascribing the smells with which we are annoyed to the bad state of the public sewer, but surely we have in the pipes and drains on our own premises (as these are usually arranged and kept), a factory of aeriform nastiness sufficient to account for our worst troubles. This unfortunate state of affairs we cannot entirely avoid; foul substances will stick to the sides of our pipes, and, being detained there, will go on and rot and produce their bad effect.

Fortunately, however, we can greatly mitigate the evil; indeed, I believe it possible, by the exercise of intelligent care in the planning and construction of a house, to reduce it to such a point, as absolutely to remove all danger and all obvious offensiveness.

The perfect sanitary formula would be: —

Allow no organic decomposition to take place within the dwelling or within any drain or pipe connected with it.

Allow no decomposition to take place under conditions favorable to the propagation of unhealthful influences.

Allow no air that has once been inside of a drain or soil pipe, to enter the house under any circumstances.

To secure the first condition named, with entire completeness, is not now possible, nor is it likely that it will become possible. All that we can reasonably hope to do is to reduce the amount of decomposition to an insignificant point. Decomposable matters

are retained within our drains in two ways: (1) by adhesion to their walls, (2) by retention in water sealed traps, though which the current is too slight to carry away solid matters.

By making all our work as smooth as possible, by avoiding horizontal or very oblique courses and irregular surfaces, we may much lessen the tendency to adhesion. By arranging for the rapid discharge of every vessel, we may give a velocity to the movement which will have a good flushing effect. We must depend on these means so far as the minor waste-pipes are concerned; but when we come to the main soil-pipe, something more is necessary.

In my opinion, it is just as important to flush a soil-pipe or a private drain, as it is to flush a public sewer, and I should feel disposed to insist upon it in every instance where it is practicable. Let there be provided on the top floor of the house, or above the junction of the highest waste, some appliance by which from 20 to 40 gallons of clear water may periodically be poured rapidly into the soil-pipe, flushing it, and the drain leading from it, with a force that will wash them clean of all filth, and we shall remove one of the greatest causes of our annoyance and danger.

The extent to which the flushing system may be advisable, will be governed entirely by the abundance of the water supply, and it is a question for the water department to consider how far water can be afforded for this use. Its general adoption would probably involve the consumption of five gallons of water *per capita, per diem.* In Philadelphia, for instance, this would amount to an addition of nearly 8 per cent. to the total consumption. Should it be found possible to devote this amount of water to the work of cleansing soil-pipes and private drains, it cannot be doubted that the beneficial effect on the public health would be most marked.

The second number of our sanitary formula relates to the character of the decomposition of such organic matter as is necessarily retained in our pipes. We have seen, that in the absence of a sufficient supply of air, the process of dissolution goes all awry. It proceeds in spite of us, and it demands oxygen for its support.

For want of a better source of this element, as I have already stated, it takes it from its own material, and then is set up a pestilent process of fermentation,—which Tyndall has aptly called, "life without air."

If we can devise means to introduce into the immediate pres-

ence of these decomposing substances a constantly renewed supply of fresh air, we shall entirely change the character of the decomposition, and secure a complete and innoxious distribution of the whole material.

It seems strange that it should have been only within the past three or four years, that means for the accomplishment of this purpose have been promulgated. Indeed, the inventors of different processes in England are wrangling over the question of precedence, and while the evidence adduced shows that the process was known years ago, it is only now struggling into anything like general adoption, though its simplicity reminds us of Columbus and the egg.

We have heard a great deal, during the past fifteen or twenty years, about the ventilation of soil-pipes, and in New York and Boston it has become an almost universal rule to carry a small lead-pipe from the highest point of the soil-pipe out through the top of the house. More recently, the size of this pipe has been considerably increased, and it is not unusual to find it equal to that of the soil-pipe itself. But all of this furnishes no ventilation. We cannot ventilate the shaft of a mine by simply uncovering its mouth. We must also supply air at the bottom, to take the place of that which is to come out at the top. If, in addition to the opening at the top, we make another at the bottom, we immediately transform all of the conditions. Obedient to the impulse of atmospheric movement, and change of temperature, a free current flows, up or down, almost without ceasing, and furnishes at every point the full supply of oxygen needed for perfect decomposition. It secures, too, the further great advantage of the immediate dilution and removal of all gaseous products of decomposition, whether harmless or hurtful, whether offensive or pure.

Our third requirement: that no air which has once been inside a drain or soil-pipe, must be permitted under any circumstances to enter the house, is at least as important as those which we have already considered.

A properly arranged system of waste-pipes and soil-pipes should be regarded as a section of "out-of-doors" brought, for convenience, within the walls of the house. The pipes, by which this exterior air is inclosed, should be of a material which will permanently exclude it from our rooms. Its joints should be as tight and lasting

as art can make them; its walls should be swept by a freely moving current of air, and they should be frequently washed by copious floods of water. All communications between utensils, in which water is used in the house, and the interior of the pipes, by which it is to be carried away, should be constantly and tightly closed against all backward movement. When we discharge our refuse into a soil-pipe, let the door be tightly closed against its re-entrance. With these conditions, we shall be as free from annoyance as though we had thrown our wastes out through the window of a castle wall and closed the sash behind it.

Under such an arrangement as I have indicated, our refuse will be as completely removed as possible; such traces as it may leave on the sides of the outlet-pipe will be subject to copious flushing; and such as may still remain, will be decomposed in the presence of abundant air.

Thus far, the efforts of sanitary plumbing have been largely confined to the production of a trap whose sealing water shall not be subject to removal by siphoning. The old idea was, that the discharge of a considerable quantity of water on the lower floor, would create a vacuum, which must be supplied by the entrance of water through a trap at a higher level. No doubt this is, to a certain extent, true, and to this extent relief was obtained by the carrying of even a small pipe to admit air directly from above the roof. It was soon found, however, that, although this arrangement protected the highest traps, there remained the further difficulty that, when water was discharged from above, its rapid passage across the mouths of the outlets below so rarefied their air that the traps gave way before the atmospheric pressure behind them.

This latter difficulty has been sought to be remedied by making the trap of such form and size that, although air may pass through it, its water shall, by its quantity or by its oscillation, restore the seal.

At the same time that this has been effected, the liability of this trap to retain organic refuse, which, under the old forms, would have been carried away, has done much to counteract the benefit.

Then again, in any case, a water-seal trap performs very imperfectly the work for which it is intended.

Dr. Fergus of Glasgow, who first demonstrated the liability of lead soil-pipes to corrosion and perforation by the action of their contained gases, has rendered a no less valuable service to

sanitary science, by his experiments on the absorption and transmission of gases by water. He showed that ammonia, presented at the outer end of an ordinary water-seal trap, produces its alkaline reaction at the inner end, in fifteen minutes. Sulphurous acid, sulphuretted hydrogen, chlorine and carbonic acid were all transmitted, so as to produce the chemical effects in from one to four hours. In another experiment he produced the rapid corrosion of a metallic wire at the house end of the pipe. The practical meaning of this is, that water acts with reference to gases, very much as a sponge does with reference to water. If our tank has sprung a leak, we had better plug the hole with a sponge than with nothing; although it will permit the water to exude, it will stop the escaping *current*. On the same principle, a water-sealed trap is very much better than no obstacle at all.

It has been found, further, that in tightly closed rooms, the air needed to supply the draught of a fireplace, may be drawn through a trap by the displacement of its seal.

These serious defects have occupied much of my attention. It seems to me that there is no way in which they may be completely overcome, except by furnishing every trap and every outlet with the added protection of a check-valve, which, while opening to pass liquids towards the drain, shall close absolutely against any movement of air towards the house. Such a check-valve will not only exclude air which might enter under pressure, or to supply the draught of chimneys, but will also form an impassable barrier between the water of the trap and the air of the drain.

Let us insert a tight, compressed rubber plug in the top of the soil-pipe above the roof, and in the foot of the soil-pipe outside of the walls of the house. We can now connect an air pump, having a mercury column gauge, at some convenient point, and force air into the whole system, until the mercury indicates a certain pressure, say 5 lbs. per square inch. If the mercury stands permanently at this point, we may be sure that the work is sound and trustworthy. If it falls, this will indicate a leakage which must be sought out and repaired. We can assure ourselves before accepting the job, that under no circumstances shall we be subject to an invasion of sewer gas into our rooms.

I have thus indicated, somewhat hurriedly, the general principles, and the methods of construction, which should guide us in arrang-

ing for the drainage of a house. In the construction of new work, there will be no difficulty in carrying out these indications quite literally. In rearranging the plumbing work of old houses, it will often be necessary, for reasons of economy or of expediency, to deviate from these instructions, to a greater or less degree; but, although I have been called to direct the alteration of the drainage of many houses in town and country, I have never yet met with a case where the essential features which I have indicated, could not be so far applied as to secure absolute immunity from danger. I ought to add, too, that I have never examined a single house, no matter how new, and how thoroughly constructed, in which serious defects did not exist.

II.—SEWERAGE.

WE come now to the question of disposing of the liquid waste of a number of houses through the medium of public sewers.

The difficulties by which we are met at the very outset, relate (1) to the manner in which the air contained in the sewer is affected by the presence and the decomposition of the foul materials which pass through it, and, (2) to the proper means for disposing of these matters after they leave the mouth of the sewer. Besides these considerations, and more or less involved with them, there arise the questions of size, form, inclination, repairs, ventilation, location of outlet, flushing, hand-cleaning, etc.

Two of the leading principles referred to in connection with house-drainage have an equally direct bearing on sewerage.

It should be our aim to permit no decomposition of organic matter within the sewer, so far as it is in our power to avoid it. Such decomposition as cannot be avoided, should take place in the presence of an abundant supply of fresh air, in order that the products of decomposition may be as far removed as possible from the dangerous character of the gases evolved, when organic substances putrefy and ferment, without the presence of sufficient oxygen.

Proper observance of these requirements is necessary, at almost every step of the work, from the first consideration of the project to the last stroke of the mason's trowel. No means have yet been devised, and none seem to be promised, which will serve to make

a sewer anything but a disagreeable necessity. By exercising the utmost care at every step of our progress, we may so mitigate its offensiveness and its danger, that a civilized community need be neither ashamed of it nor afraid of it.

I trust that the sewers of your city are free from some of the grave defects of the older sewers of New York and Boston, which have been fitly described as being highest at the lower end, lowest in the middle, biggest at the little end, receiving branch sewers from below, and discharging at their tops; elongated cesspools, half filled with reeking filth, peopled with rats, and invaded by every tide; huge gasometers, manufacturing day and night a deadly aeriform poison, ever seeking to invade the houses along their course; reservoirs of liquid filth, ever oozing through the defective joints, and polluting the very earth upon which the city stands.

This description applies in its entirety to few, if any, remaining sewers, but the number of large brick sewers in either of the cities named, built in the first half of this century, which are not amenable to more than one specification of the charges, is extremely small.

The number of large brick sewers in any city, of however recent construction, not amenable to some of these charges, is, perhaps, even smaller.

This may seem to many, who have lived all their lives on sewered streets, to be an exaggerated statement, but I am satisfied that a sufficient investigation of the subject will convince them that it is not so.

What are now regarded as the requirements of a thoroughly good sewer, may be stated as follows:—

It should be so tight as to prevent its liquid contents from leaking, or leaching into the ground.

Its fall, or inclination, which need not be great, should be constant, so that there may be no sluggish flow, and, above all, no dead water at any point.

It should be so thoroughly ventilated, that the filth which smears its walls may always decompose in the presence of an ample supply of atmospheric air; that the gaseous products of such decomposition may be copiously diluted and speedily removed; that it will be easier for those gases, so diluted, to escape through chan-

nels purposely provided for them, than through pipes leading to the interior of houses; and that any pressure brought to bear on the contained atmosphere, either by an increase of the volume of the flow, by an increase of temperature, by the rise of tide-water in its outlet, or by the force of wind blowing against its mouth, may find easy relief.

It should discharge at its outlet, within a very few hours, every substance that it has received.

It should be supplied with such appliances for flushing, as shall insure its periodical cleansing of whatever substances that may have found lodgment on its walls, save only the slight sliming; which no practicable flushing can remove.

A sewer which meets all of these requirements may be regarded as the best device which human ingenuity has yet provided, for carrying away the offscourings of houses. No single item in connection with sewer construction, has been the subject of so much dispute, and is still so far from a universally satisfactory solution, as the matter of *size*. Whether sewers, intended for the removal of house wastes, shall be made large enough to remove also the water of copious thunder storms, is a question, about which engineers are still in dispute. There is much to be said on both sides of the question, and I do not profess to be able to decide it in a way that shall be universally satisfactory. My own conviction, however, is very clear that storm-water should be kept out of the sewers, which carry house wastes, where other means can be provided, at practicable cost, for its removal.

Having a firm belief that the sanitary condition of any town is influenced more by the details than by the *ensemble* of its drainage work, I shall confine myself chiefly to the consideration of such sewers as serve to drain side streets, which are mainly the streets of residence.

I should make such a sewer only large enough,—adopting a diameter of six inches as a minimum,—to carry the drainage of the houses along its line and a very small amount of rainwater,—say the first few minutes' fall of a shower and the whole flow of a very light rain.

I should *prefer* to make the sewer of such a size, that the ordinary forenoon flow, of house drainage only, should fill it half full, not admitting more rainfall than would fill it to its greatest capacity.

If we can make sure that at least at that part of the day when the discharge from the house drains is most copious,—say from eight to eleven in the morning,—the sewer shall be running half full, we shall provide, in the best manner, for its thorough flushing by its own unaided current.

The size of sewer requisite to meet this condition is astonishingly small. For example: a pipe 6 inches in diameter, having an inclination of 4 inches in 100 feet, has a capacity of discharge of nearly 200 gallons per minute,—say 12,000 gallons per hour, or between eight and eleven in the morning, 36,000 gallons. It is usual to estimate that during these three hours, about one-third of the daily flow is discharged. Such a pipe, then, at such an inclination, would be adequate to the removal of over 100,000 gallons per day. Suppose, now, that each household numbers six persons, and that the consumption of water is 33⅓ gallons per head per day. The pipe would therefore serve for the drainage of 500 houses, or, supposing it to run only half full between eight and eleven in the morning, for 250 houses.

Allowing a width of only 12½ feet for each house, it would serve for a street over 1,500 feet long, closely built up on both sides.

There is no theoretical objection, if we can devise some other means for getting rid of storm-water, to adopting sewers of very much smaller size, and, consequently, of very much less cost than is usual for all of our purely domestic drainage service.

On the other hand, there is the very great advantage that sewers, whose capacity is regulated to the amount of work which they have to perform, are quite sure to keep themselves clean. The flushing power of their current will be sufficient to carry forward to the outlet, or to the junction with a large sewer, every substance of whatever character, that can gain access to them,—they being protected against the entrance of bulky matters by having no inlet, whether from a house or from a street gutter, more than 4 inches in diameter.

It is usual in the ordinary practice of sewerage, in many places, to use no pipe smaller than 12 inches in diameter. Such a pipe laid on an inclination of 1 in 600,—or 2 inches per 100 feet,—has a discharging capacity of 400,000 gallons per day, and, on the basis of the calculation just made, it would, if running half-full, suffice

for the drainage of 1,000 houses occupying over 6,000 feet of street closely built up on both sides.

I am well aware, that the use of pipes of small diameter implies a strict adherence to what is known as "The Separate System of Drainage," all the surface water, except the small and foul first flow of a heavy storm, and the whole of a light rain, being removed by separate channels. I am not so Quixotic as to recommend the use of pipes so small as 6 inches for any considerable length of city sewer, for, in the present condition of the drainage art, the prejudice in favor of making all drains "big enough anyhow," would compel the use of larger sizes. But I should contest the prejudice as vigorously as possible, and insist on a reasonable adjustment of the size of the drain to the amount of work it would have to perform.

Let us assume that, as a compromise between the smallest pipes, which are theoretically adapted to the work, and the popular notion in favor of large conduits, we adopt a diameter of 12 inches for all subsidiary drains. Let us see how we may best go to work to make such a drain conform to the requirements which I have set forth.

Whether the sewer is made of earthen-ware pipe, of hard-burned bricks, or of iron,—the only three appropriate materials for the work,—its joints must be made in the most thorough manner, and with the best material, lead in the case of iron pipes, and the best cement in all other cases. The advantage, under certain circumstances, of having a sewer act as a land drain for the removal of excessive soil-water is more than counterbalanced, in time of drought, by the escape of foul sewage into the ground.

Practically, it is a matter of extreme difficulty to make a brick sewer tight; but pipe sewers, laid on a firm foundation, and jointed with tarred gaskets and good cement mortar, are easily made absolutely so. However slight the inclination, the greatest care should be taken to secure its uniformity. The less the fall, the greater the care required. The requisite cleansing velocity of 120 feet per minute must be not an *average*, but a constant velocity. Any depression in the grade, causing a less rapid flow, or absolute dead water, leads to the deposit of silt, which aggravates the difficulty. When the inclination of the line is very great, slight deviations are of less consequence, but, except on steep grades, the

constant care of the surveyor should be exercised to maintain the exact fall.

Tightness and regular inclination being secured, insuring the constant movement toward the outlet of all foul contents, the next great requirement is thorough ventilation. To secure this, has taxed to the utmost the skill and ingenuity of all sanitary engineers. The use of fan blowers, of tall chimneys, of fires, of falling spray, and of all other known devices, has been advocated by one and another, and all have been applied, usually with doubtful success.

The experience of the world seems to have demonstrated that there are but two means by which a satisfactory result may be obtained. (1) By free communication with the atmosphere, at intervals not exceeding 100 yards, through manholes covered with open gratings; (2) by requiring every house-drain to be in untrapped communication with the sewer, and to afford a free passage, of its full diameter, through the soil-pipe to an open end above the house. Either of these systems produces a reasonably satisfactory result; but a combination of the two is necessary to perfect ventilation.

If every sewer is in free communication with the air, through open gratings at each manhole, (and at the intervals indicated); and if every house furnishes a 4 inch ventilator, rising high in the air, the sewer will, under all circumstances, have such a free circulation and such a constant renewal of its atmosphere, that, even though it contains more or less decomposing materials, it can never become a source of what is popularly known and dreaded as "sewer gas." Sewers, so ventilated, produce no offence, even in the immediate vicinity of the manholes, and are, so far as their effluvium is concerned, entirely unobjectionable and safe.

This system of ventilation through soil-pipes, if undertaken at all, must be compulsory and universal. We cannot ask Mr. A. to furnish a channel through his house for the air of a sewer which Mr. B., and Mr. C. and Mr. D. exclude; but if every man, who is permitted to discharge filth into it, is compelled to furnish his quota of ventilation, and if there is a free inlet for air at each manhole, each soil-pipe will deliver a current which might almost be discharged without danger, at the level of the street, and under the noses of passers by, instead of being sent out into the free air above the roofs of the houses. A sewer, so ventilated, will accom-

plish all that I have indicated as a necessary requirement, under every condition.

In order to secure a prompt discharge of its contents, it must have an inclination which will give its current a velocity of at least 120 feet per minute, *i. e.* its current should have this velocity at some time during each day. However great the inclination, in practice the flow near the upper end will rarely be sufficient to overcome the friction due to the width of channel; and the deposit of silt will be quite a matter of course. Especially when the ground is nearly level, the flow must necessarily be sluggish, until, at a considerable distance from the head of the sewer, the constant additions to the stream shall have given it a cleansing depth. To overcome deposits of silt, and further to remove the sliming of the walls, occasional flushing is important. The efficient means for accomplishing this are various, but none seems to me to promise so good a result as the recent application, by Mr. Rogers Fields of London, of his flush-tank principle.

By the application of this principle, a large flush tank is made to receive all the drainage of a certain number of houses, at the head of each sewer,—at least enough to fill it every twenty-four hours. As soon as it becomes filled, the whole accumulation is driven down the branch lines and through the subsequent main sewers with a force sufficient to remove all accumulations.

A sewer, not too large for its work, arranged as above indicated, is as good as, in the present state of engineering knowledge, it can be made.

I regard this question of the construction and arrangement of minor sewers, together with the construction and arrangement of house-drains, as being far more important to the public health than the more obvious matter of the ultimate disposal of the outflow.

It seems to me, therefore, that the City of Boston, in its proposed outfall sewers, is beginning quite at the wrong end of its work, and is devoting itself to the remedy of a comparatively minor evil. As a piece of engineering work, the task which it is now undertaking is truly monumental; but, even assuming that the result will meet the expectations of the projectors, there will still be left to be provided for, the removing from every street of the city a source of offence and danger, compared with which, the question of ultimate disposal is almost insignificant.

London, a few years ago, spent $20,000,000, in an attempt to secure a permanent solution of the outfall question. Recent indications all point to the conclusion, that the attempt has resulted in failure; and that fresh millions must be spent in seeking a satisfactory solution of the terrible problem.

If London cannot safely pour its outfall into the Thames, miles away from the city, discharging it only in the copious ebb tide of that river, it becomes a serious question whether Philadelphia can always discharge her sewage into the Delaware, at any point to which it would be practible to carry the outfall sewage.

My knowledge of your local conditions is far too little to warrant me in suggesting a remedy; but I will venture to indicate certain principles which seem to me applicable to all cities, and which may be worthy of consideration here. They relate to the disposal of the wastes of the closely built part of the city, and of the disposal of the wastes of the manufacturing villages and smaller towns which are included within your limits, or which, from lining the banks of the Schuylkill [which should be your best source of water supply,] tend toward its contamination.

In England, attempts have been made, in some cases on a very large scale, to effect the deposit of matters, held in suspension, in large settling tanks, by various chemical and mechanical processes. So far as I know, none of these experiments has resulted satisfactorily. When sewage has been discharged into the sea, or, at ebb tide, into tidal rivers, the removal of sewage matters has been much less complete than was anticipated, largely from the fact that the erosive power of the flood tide is greater than that at the ebb.

The sewage of Dover (discharged where experiments with floats indicated that it would be entirely removed,) is brought back on the foreshore by the flood tide, in objectionable amount. The same difficulty is said to exist at Brighton. When the great outfall works were built at Barking, 11 miles below London, it was believed that each ebb tide, supplemented, as it is, by the fresh water flow of the stream, would carry the deposits steadily onward toward the sea. It is now found that the greater power of the flood tide carries it constantly farther up the stream, and it has appeared in alarming quantities quite up to Blackwell.

What would be the ultimate effect of a similar discharge into

the Delaware at League Island, can only be surmised, but the experience of London indicates that a similar course, adopted here, might result unfavorably, though the greater volume of the Delaware would be in your favor.

If we are to assume, from English experience, that, to discharge our sewage into tidal rivers, or to attempt its purification by mechanical or chemical deposition, will only result in failure, we are driven so far as we now know, to the adoption of one of two remaining methods: (1) the Liernur Pneumatic System or, (2) the purification of sewage by application to the land.

Liernur's system, which removes all sewage admitted to his iron pipes through vacuum chambers, and finally to receptacles near his air-pump engines, where it is so dessicated that the solid residue is salable as manure, is too new to be considered as applicable to large cities like Philadelphia, except as a last resort, and after careful investigation. It works well in Dordrecht, and in Leyden, and after years of experience at Amsterdam the authorities have ordered its extension over a large part of the town. At the same time, its use in any American town would involve too great a modification of our habits of life for it to be now regarded as feasible.

The process of purification by application to the land has been measurably successful, with greater or less drawbacks, in numerous cases in England; but, on the whole, what is there known as sewage farming has generally proved to be a losing business; and engineers are divided in opinion as to its future.

There have been two somewhat extensive experiments with Dr. Frankland's system of "intermittent downward filtration",—Merthyr-Tydvil in Wales, and the other at Kendal.

These have demonstrated that an acre of porous soil, deeply under-drained, so as to be aerated to a depth of at least 6 feet, is capable of purifying the sewage of a population of 2,500, so as to bring the effluvient to a potable condition.

The land is laid out in several separate areas, each crossed with alternate ridges and furrows. The sewage is accumulated in a flush-tank which discharges a sufficient amount to give a saturating flow over any one of the areas. Of four areas, three are in use, alternately,—one each day, or half day, as the case may be. The fourth area is kept out of use during a whole year, save when occasionally needed for storm-water. At the end of the year this is used as one of

the three, and the one which has been longest in use is thrown out for the next. The ridges are planted with mangel-wurtzel, cabbage, Italian rye grass, or some other crop of strong growth.

At each discharge from the tank, the ditches between these ridges are filled to a considerable depth. The water settles rapidly away to the level of the drains, leaving its impurities attached to the interior surfaces of the soil. As it descends in the ground, it is followed by fresh air which, during the interval between the successive floodings, effects the decomposition of the foreign substances, and, as is found in practice, the entire purification of the ground,—being aided, of course, so far as the upper portions are concerned, by the roots of plants with which it is permeated. It is very likely that our more frequent severe frosts might operate as a serious drawback to the operation of the system, but if, instead of attempting to grow grass or vegetables on our ridges, we plant them with osiers, it is probable that the shelter which these would afford, together with the warmth of the sewage, would prevent serious trouble from freezing.

It may be found that no serious objection exists to distributing sewage to these absorption beds through porous conduits, lying for a short distance below the surface, and so protected against the frost. Certainly this system works perfectly for the disposal of the drainage of single houses.

So far as the closely built part of your city is concerned, I am very far from recommending this comparatively new system as applicable to your needs. Indeed, a question of such magnitude may well tax the most careful study of the most competent engineers, and, even then, it is fair to assume that the work would be more or less experimental in its character,—but it is an experiment well worth trying.

I am, however, inclined to think that the system of intermittent, downward filtration *may* offer a perfect solution of your problem, so far as the towns on the banks of the Schuylkill are concerned. Indeed, the case of Merthyr-Tydvil,—with a population of 14,000,—furnishes unquestionable evidence of its fitness for such work. It might serve, too, for communities like Germantown, and all of your smaller outlying settlements; and the more you are able to provide for your sewage in detail, reducing your main problem to the simplest possible terms, the easier will its permanent solution become.

A most important means for still further simplifying this problem is to be sought in a thorough system of street cleaning. If we consider all the difficulties, arising from foul matters admitted to our sewers, we shall see that the most expensive and troublesome surface scavenger that we can have, is the rain that falls from heaven and washes the dirt of the public streets into the public sewer.

PRESS OF EDWARD STERN & CO.